OCR
Oxford Cambridge and RSA

A Level Physics A

H556/01 Modelling physics

Thursday 15 June 2017 – Morning

Time allowed: 2 hours 15 minutes

You must have:
- the Data, Formula and Relationship Booklet (sent with general stationery)

You may use:
- a scientific or graphical calculator
- a ruler (cm/mm)

First name	
Last name	
Centre number	Candidate number

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **32** pages.

© OCR 2017 [601/4743/X]
OCR is an exempt Charity
DC (RW/SW) 153005/7 **R**

SECTION A

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box.

Answer **all** the questions.

1 Which of the following is a correct unit for gravitational field strength?

A $J\,kg^{-1}$

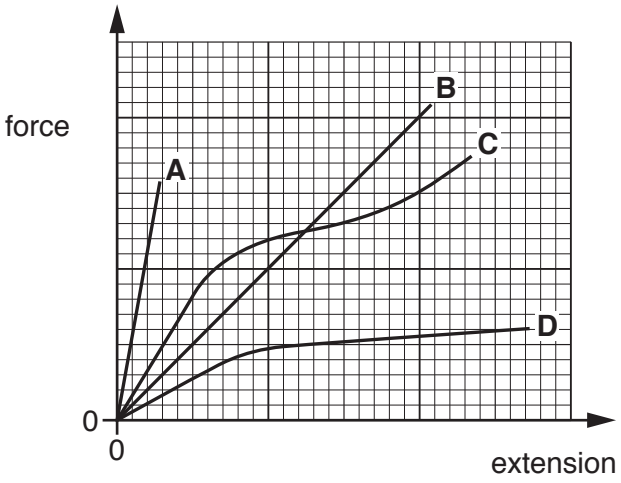
B $N\,kg^{-1}$

C $N\,m^2\,kg^{-2}$

D $kg\,m\,s^{-1}$

Your answer ☐ **[1]**

2 Four materials **A**, **B**, **C and D** have the same length and cross-sectional area. The force against extension graph for each material up to the breaking point is shown below.



Which material is brittle and has the greatest ultimate tensile strength?

Your answer ☐ **[1]**

© OCR 2017

3 The braking distance of a car is directly proportional to its initial kinetic energy.

The braking distance of a car is 18 m when its initial speed is $10\,m\,s^{-1}$.

What is the braking distance of the car, under the same conditions, when its initial speed is $25\,m\,s^{-1}$?

A 7.2 m

B 45 m

C 113 m

D 222 m

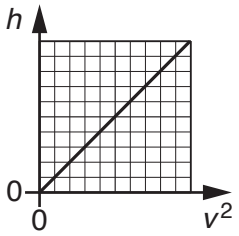
Your answer ☐ **[1]**

4 A ball is dropped from rest above the ground. Air resistance has negligible effect on the motion of the ball.

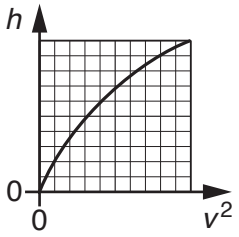
The speed of the ball is v after it has fallen a distance h from its point of release.

Which graph is correct for this falling ball?

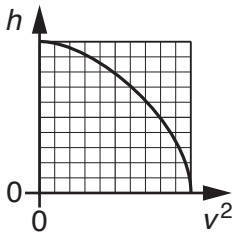
A



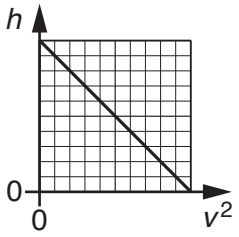
B



C



D



Your answer ☐ **[1]**

© OCR 2017

5 Which is the **best** estimate of the area of a rectangular field of length 98 ± 3 m and width 47 ± 2 m?

A $4600 \pm 5\,m^2$

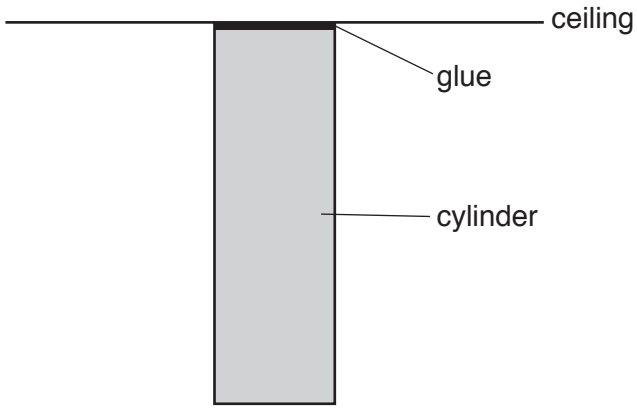
B $4600 \pm 6\,m^2$

C $4600 \pm 300\,m^2$

D $4606 \pm 337\,m^2$

Your answer ☐ **[1]**

6 The flat end of a uniform steel cylinder of weight 7.8 N is glued to a horizontal ceiling. The cylinder hangs vertically. The breaking stress for the glue is 130 kPa.



The glue only just holds the cylinder to the ceiling.

What is the cross-sectional area of the cylinder?

A $6.0 \times 10^{-2}\,m^2$

B $6.0 \times 10^{-5}\,m^2$

C $1.7 \times 10^{-2}\,m^2$

D $1.7 \times 10^{1}\,m^2$

Your answer ☐ **[1]**

© OCR 2017

7 The intensity against wavelength graph of an object at 750 °C peaks at a wavelength of λ. The temperature of the object is raised to 960 °C.

What is the wavelength now at the new peak intensity in terms of λ?

A 0.78λ

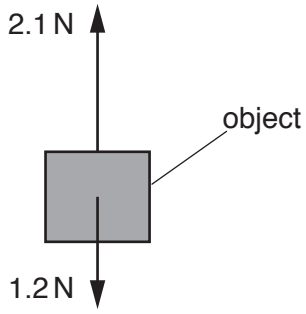
B 0.83λ

C 1.2λ

D 1.3λ

Your answer ☐ **[1]**

8 The diagram shows two opposite vertical forces of magnitude 1.2 N and 2.1 N acting on an object.



Which of the following statements could be correct?

1 The object is accelerating and moving up.
2 The object is decelerating and moving down.
3 The magnitude of the resultant force is 0.9 N.

A Only 3

B Only 1 and 3

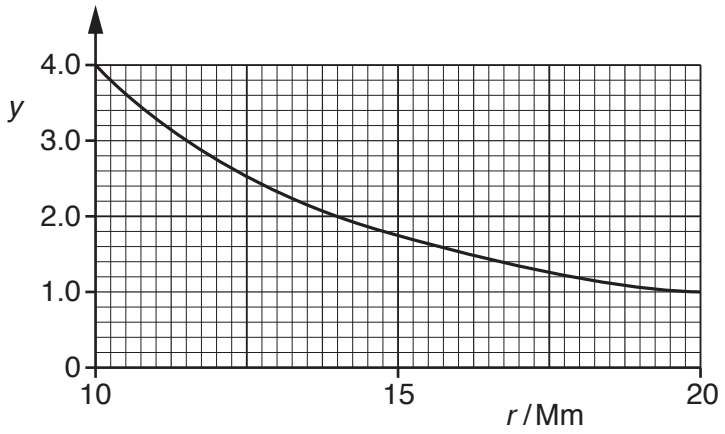
C Only 2 and 3

D 1, 2 and 3

Your answer ☐ **[1]**

© OCR 2017

9 A graph of y against distance r from the centre of a planet is shown below.



The graph shows that y is inversely proportional to r^2.

Which quantity is best represented on the y-axis of the graph?

A Period of a satellite orbiting the planet.

B Gravitational potential of the planet.

C Gravitational field strength of the planet.

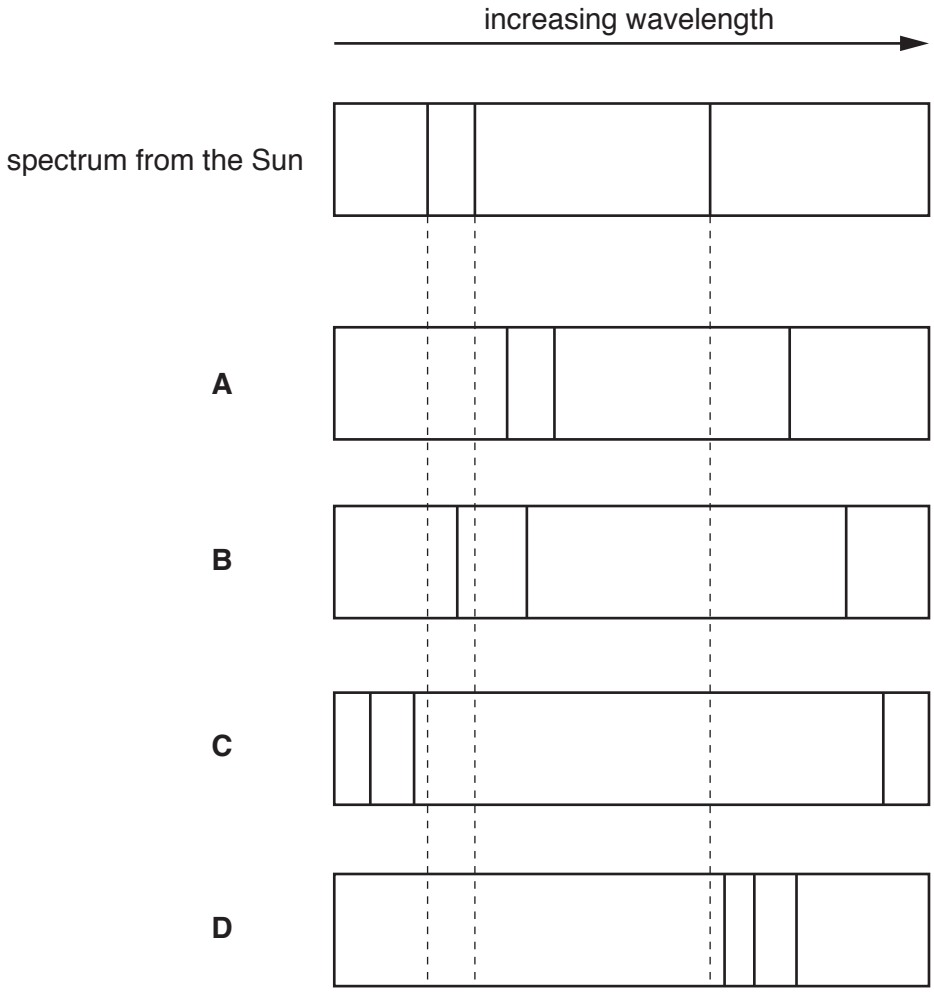
D Kinetic energy of a satellite orbiting the planet.

Your answer ☐ **[1]**

© OCR 2017

10 Part of the line spectrum for light from the Sun is shown below.

Which spectrum best shows light from a similar star to the Sun?



Your answer ☐ **[1]**

11 A tensile force of 4.5 N is applied to a spring. The spring extends elastically by 3.2 cm.

What is the elastic potential energy of the spring?

A 0.072 J

B 0.14 J

C 2.4 J

D 14 J

Your answer ☐ **[1]**

© OCR 2017

12 An object above the ground is released from rest at time $t = 0$.

Air resistance is negligible.

What is the distance travelled by the object between $t = 0.20\,s$ and $t = 0.30\,s$?

A 0.20 m

B 0.25 m

C 0.44 m

D 0.49 m

Your answer ☐ **[1]**

13 A puck of mass 0.16 kg is sliding on ice with a constant velocity of $11.0\,m\,s^{-1}$. A hockey stick exerts a force on the puck, for a short period of time, in the **opposite** direction to the velocity of the puck. The momentum of the puck changes by $2.0\,kg\,m\,s^{-1}$.

Ignore friction.

What is the speed of the puck when it leaves the hockey stick?

A $1.5\,m\,s^{-1}$

B $3.8\,m\,s^{-1}$

C $12.5\,m\,s^{-1}$

D $23.5\,m\,s^{-1}$

Your answer ☐ **[1]**

© OCR 2017

14 A container has an ideal gas. The mean square speed of the gas molecules in the container is $3.0 \times 10^5 \text{m}^2\text{s}^{-2}$.

Over a period of time, a third of the gas molecules escape from the container. The pressure and volume of the gas in the container remain the same.

What is the mean square speed of the molecules left in the container?

A $1.0 \times 10^5 \text{m}^2\text{s}^{-2}$

B $2.0 \times 10^5 \text{m}^2\text{s}^{-2}$

C $4.5 \times 10^5 \text{m}^2\text{s}^{-2}$

D $9.0 \times 10^5 \text{m}^2\text{s}^{-2}$

Your answer ☐ **[1]**

15 Which two quantities are related in Hubble's law?

A Distance and mass of galaxies.

B Velocity and intensity of galaxies.

C Distance and velocity of galaxies.

D Distance and red shift of stars in our galaxy.

Your answer ☐ **[1]**

© OCR 2017

SECTION B

Answer **all** the questions.

16 Fig. 16 shows a hydraulic jack used to lift a car which has a mass of 1200 kg. A mechanic exerts a downwards force of 400 N on the handle of the jack, moving it 80.0 cm downwards. As he moves the handle, the car rises 2.0 cm.

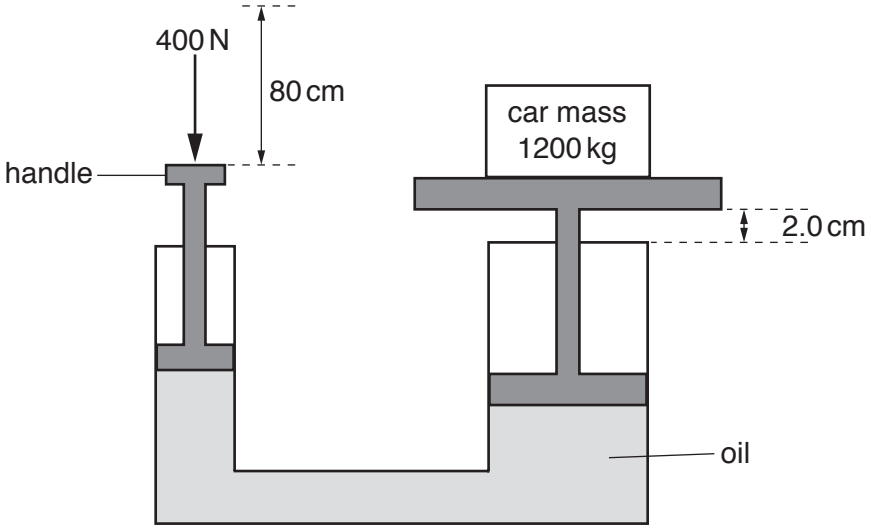


Fig. 16

(a) Calculate the work done by the 400 N force exerted by the mechanic.

work done = ... J **[2]**

© OCR 2017

(b) Calculate the ratio

$$\frac{\text{speed of handle moving down}}{\text{speed of car moving up}}.$$

ratio = ... **[2]**

(c) Calculate the useful work done on the car and hence the percentage efficiency of the jack.

efficiency = ... % **[2]**

© OCR 2017

17 A group of students are conducting an experiment in the laboratory to determine the value of absolute zero by heating a fixed mass of gas. The volume of the gas is kept constant.
Fig. 17.1 shows the arrangement used by the students.

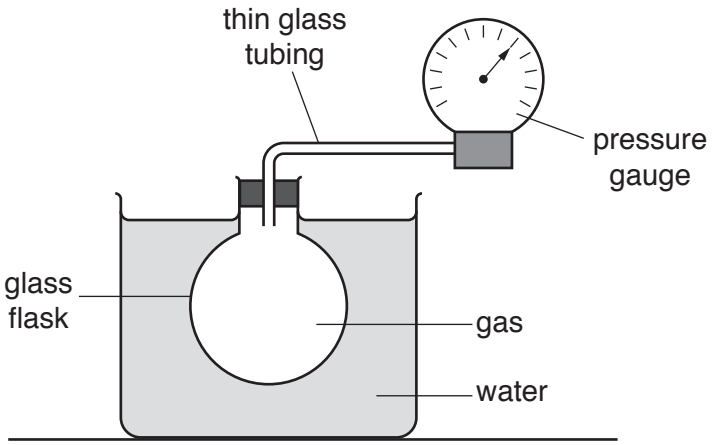


Fig. 17.1

The gas is heated using a water bath. The temperature θ of the water is increased from 5 °C to 70 °C. The temperature of the water bath is assumed to be the same as the temperature of the gas. The pressure p of the gas is measured using a pressure gauge.

The results from the students are shown in a table.

θ / °C	p / kPa
5 ± 1	224 ± 3
13 ± 1	231 ± 3
22 ± 1	238 ± 3
35 ± 1	248 ± 3
44 ± 1	
53 ± 1	262 ± 3
62 ± 1	269 ± 3
70 ± 1	276 ± 3

(a) Describe and explain how the students may have made accurate measurements of the temperature θ.

.....

.....

..... **[2]**

© OCR 2017

(b) Fig. 17.2 shows the pressure gauge. Measurements of p can be made using the kPa scale or the psi (pounds per square inch) scale. The students used the psi scale to measure pressure and then converted the reading to pressure in kPa.

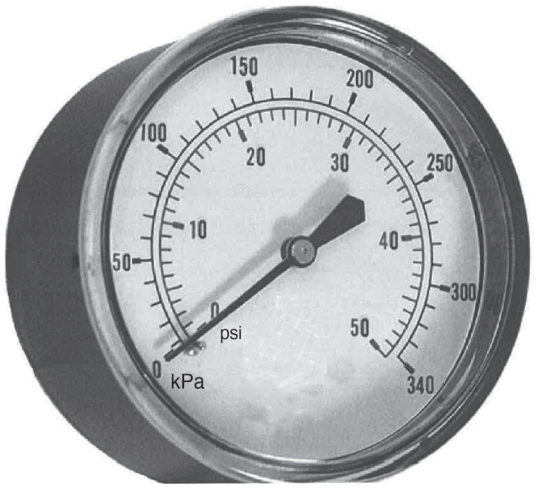


Fig. 17.2

(i) Suggest why it was sensible to use the psi scale to measure p.

.....

..... **[1]**

(ii) The students made a reading of p of 37.0 ± 0.5 psi when θ was 44 ± 1 °C.
Convert this value of p from psi to kPa. Complete the table for the missing value of p. Include the absolute uncertainty in p.

1 pound of force = 4.448 N
1 inch = 0.0254 m

[2]

© OCR 2017

(c) Fig. 17.3 shows the graph of p against θ.

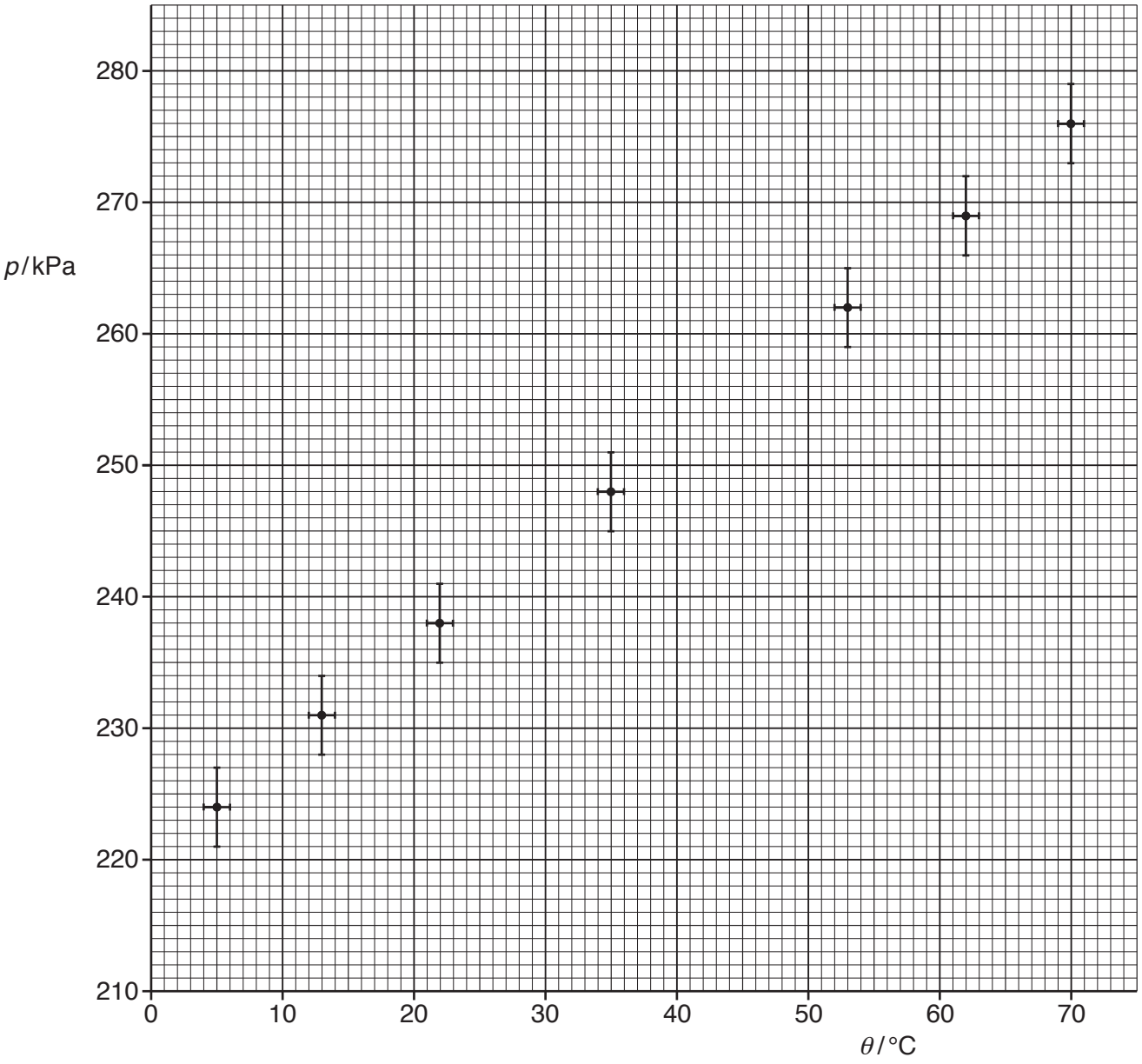


Fig. 17.3

(i) Plot the missing data point and the error bars on Fig. 17.3. **[1]**

© OCR 2017

(ii)* Explain what is meant by *absolute zero*. Describe how Fig. 17.3 can be used to determine the value of absolute zero.
Determine the value of absolute zero. You may assume that the gas behaves as an ideal gas.

.....

.....

.....

(d) Describe, without doing any calculations, how you could use Fig. 17.3 to determine the actual uncertainty in the value of absolute zero in **(c)(ii)**.

.....

.....

.....

..... **[2]**

(e) The experiment is repeated as the water bath quickly cools from 70 °C to 5 °C. Absolute zero was found to be −390 °C.

Compare this value with your value from **(c)(ii)** and explain why the values may differ. Describe an experimental approach that could be taken to avoid systematic error in the determination of absolute zero.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

© OCR 2017

18 A swimming pool designer investigates the depth *d* below a water surface reached by a diver when diving from a height *h* above the water surface. The designer models the diver as a uniform wooden cylinder. The experimental arrangement is shown in Fig. 18.1.

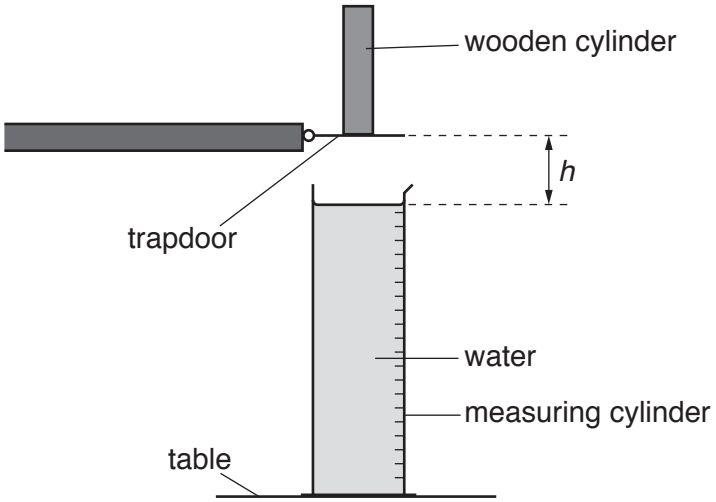


Fig. 18.1

(a) The wooden cylinder has mass 5.0×10^{-3} kg, diameter 1.0×10^{-2} m and length 7.0×10^{-2} m.

(i) Calculate the density of the wood.

density = ... $kg\,m^{-3}$ **[2]**

(ii) Suggest why wood is an appropriate material to model the depth reached by a diver.

.....

.....

.....

..... **[2]**

© OCR 2017

(b) The cylinder is released from **rest** from a trapdoor. The base of the cylinder is at a height $h = 0.30\,\text{m}$ above the water surface.
Calculate the speed of the cylinder just before the base hits the water. Ignore air resistance.

speed = ... m s^{-1} **[2]**

(c) Fig. 18.2 shows the cylinder fully submerged under the water surface before it has come to rest. The cylinder is moving vertically **down**.

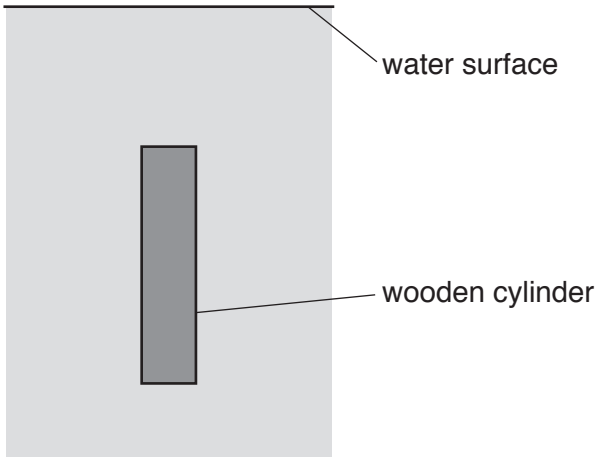


Fig. 18.2

(i) Add arrows to Fig. 18.2 to show the **three** forces acting on the wooden cylinder. Label the arrows. **[3]**

(ii) Describe and explain how the **resultant** force on the wooden cylinder varies from the moment the cylinder is fully submerged until it reaches its deepest point.

.....

.....

.....

.....

.....

..... **[3]**

© OCR 2017

(d) The graph of Fig. 18.3 shows the depth *d* reached for different initial drop height *h*.

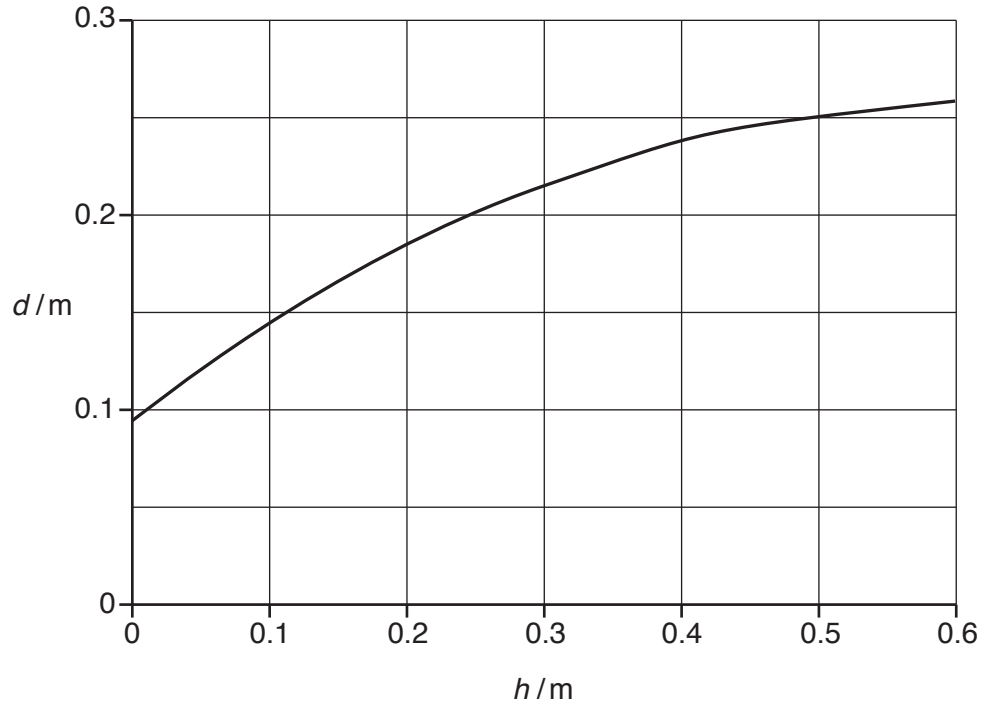


Fig. 18.3

The designer is required to double the height of a diving board for an existing swimming pool. He suggests that the depth of the pool also needs to be doubled.
Use Fig. 18.3 to explain whether you agree with this suggestion.

.....

.....

.....

.....

..... **[2]**

© OCR 2017

19 This question is about a simple pendulum made from a length of string attached to a mass (bob).
For oscillations of small amplitude, the acceleration a of the pendulum bob is related to its displacement x by the expression

$$a = -\left(\frac{g}{L}\right)x$$

where g is the acceleration of free fall and L is the length of the pendulum.
The pendulum bob oscillates with simple harmonic motion.

(a) (i) Show that the period T of the oscillations is given by the expression

$$T^2 = \frac{4\pi^2}{g}L.$$

[3]

(ii) A student notices that the amplitude of each oscillation decreases over time.
Explain this observation and state what effect this may have on T.

.....

.....

.....

..... **[2]**

© OCR 2017

(b)* Describe with the aid of a labelled diagram how an experiment can be conducted and how the data can be analysed to test the validity of the equation $T^2 = \frac{4\pi^2}{g}L$ for oscillations of small amplitude.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[6]**

© OCR 2017

(c) Another student conducts a similar experiment in the laboratory to investigate the small amplitude oscillations of a pendulum of a mechanical clock. Each 'tick' of the clock corresponds to **half** a period.

(i) Show that the length of the pendulum required for a tick of 1.0 s is about 1 m.

[2]

(ii) If the pendulum clock were to be used on the Moon, explain whether this clock would run on time compared with an identical clock on the Earth.

.....

.....

.....

..... **[2]**

© OCR 2017

20 A plastic kettle is filled with 0.60 kg of water at a temperature of 20 °C.
A 2.2 kW electric heater is used to heat the water for a time of 4.0 minutes.

(a) Calculate the total energy supplied by the heater during the time of 4.0 minutes.

energy = ... J **[2]**

(b) The specific heat capacity of water is 4200 J kg^{-1} K^{-1} and the specific latent heat of vaporisation of water is 2.3 × 10^{6} J kg^{-1}. The boiling point of water is 100 °C.

Calculate the mass of water **remaining** in the kettle after 4.0 minutes.
Assume that all the thermal energy from the heater is transferred to the water.

mass of water remaining = ... kg **[4]**

© OCR 2017

21 **(a)** Fig. 21.1 shows some of the energy levels of electrons in hydrogen gas atoms. The energy levels are labelled **A**, **B**, **C** and **D**.

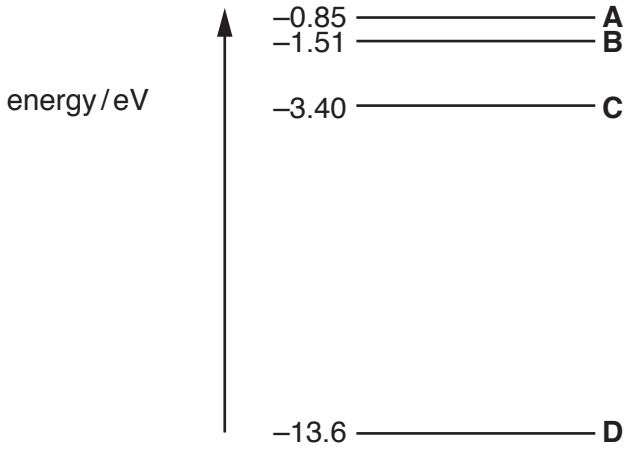


Fig. 21.1 (not to scale)

(i) Explain why the energy levels are negative.

.....

..... **[1]**

(ii) An electron makes a transition (jump) from level **C** to level **A**.

1 Calculate the energy gained by this electron.

energy = ... eV **[1]**

2 Calculate the wavelength in nm of the photon absorbed by this electron.

wavelength = ... nm **[3]**

© OCR 2017

(b) Light from a distant galaxy is passed through a diffraction grating. Fig. 21.2 shows the part of the spectrum of light that shows a strong hydrogen-alpha emission line.

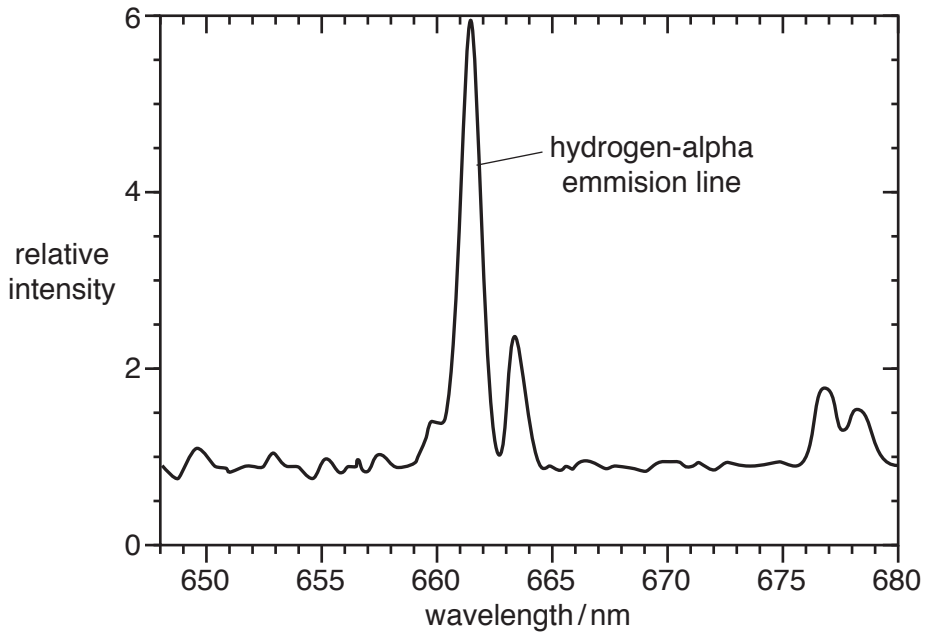


Fig. 21.2

(i) State how an emission line is produced.

.....

..... **[1]**

(ii) State an adjustment that could be made to the experimental arrangement that would space the emission lines more widely.

.....

..... **[1]**

(iii) In the laboratory, the wavelength of the hydrogen-alpha emission line is 656.3 nm. Use Fig. 21.2 to determine the recession velocity of the galaxy.

recession velocity = ... $m\,s^{-1}$ **[3]**

© OCR 2017

(iv) Suggest why hydrogen spectral lines play an important role in determining red shift of galaxies.

.....

..... **[1]**

(c) Light from a similar star is viewed in a galaxy **further** away. The star is part of a pair of stars which orbit a common centre of mass.
Describe and explain how the equivalent spectrum might appear.

.....

.....

.....

.....

.....

.....

..... **[3]**

© OCR 2017

22 **(a)** Define the *internal energy* of a substance.

.....

.....

..... **[1]**

(b) A block of paraffin wax is melting at a constant temperature of 52 °C. Use the behaviour of paraffin molecules to describe and explain the changes to the internal energy of the molecules of the paraffin wax as it melts.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

© OCR 2017

23 **(a)** Write an expression for the gravitational potential V_g at the surface of a planet of mass M and radius r.

[1]

(b) The table below shows some data for Mercury and Pluto.

	Mass / kg	**Radius / m**	**Mean distance from Sun / m**
Mercury	3.30×10^{23}	2.44×10^{6}	57.9×10^{9}
Pluto	0.131×10^{23}	1.19×10^{6}	5910×10^{9}

(i) Show that the escape velocity v of a gas molecule on the surface of Pluto is given by the equation

$$v = \sqrt{\frac{2GM}{r}}$$

where M is the mass of Pluto and r is its radius.

[2]

(ii) Calculate the escape velocity v of gas molecules on the surface of Pluto.

v = ... $m\,s^{-1}$ **[1]**

© OCR 2017

(iii) Explain why Mercury has no atmosphere whilst Pluto still has a thin atmosphere. Use data from the table to support your explanation.

.....

.....

.....

.....

.....

.....

..... **[3]**

END OF QUESTION PAPER

© OCR 2017

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

© OCR 2017

© OCR 2017

OCR
Oxford Cambridge and RSA

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact the Copyright Team, First Floor, 9 Hills Road, Cambridge CB2 1GE.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

© OCR 2017